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NEW PATENT APPLICATION

MEGASONIC CLEANING VESSEL USING SUPERCRITICAL CO2

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MEGASONIC CLEANING VESSEL USING SUPERCRITICAL CO2

TECHNICAL FIELD

This present invention relates to a cleaning vessel employing megasonic energy to clean materials, especially, semiconductor wafers.

BACKGROUND ART

When processing semiconductor wafers, it is necessary to remove contaminants from the surfaces of these semiconductor wafers. These contaminants consist of organic and inorganic materials in the form of particulate, and have been removed using ultrasonic energy (20-200 Kilohertz). For example, the semiconductor wafers are submerged in a liquid. The liquid is used as a working medium, and the ultrasonic energy is applied thereto. The ultrasonic energy causes the liquid to cavitate, and to thereby form vacuum bubbles that subsequently collapse. The formation and collapse of these bubbles in the working medium releases energy, and the working medium is agitated by this energy. The agitation in the working medium is enough to dislodge large particulate from the semiconductor wafers.

To dislodge very small particulate, however, agitation caused by the energy released through the formation and collapse of vacuum bubbles is inadequate. Therefore, megasonic energy (200-2000 Kilohertz) has been used instead of ultrasonic energy. For example, megasonic energy does not allow the liquid used as the working medium to cavitate. Therefore, the megasonic energy can be transmitted through the working medium, and be applied directly to the semiconductor wafers. The direct application of the megasonic energy has been effective in removing small particulate.

However, when liquid is used as the working medium, it is difficult to fill the

cleaning vessel. Generally, liquids have high viscosities, and, therefore, significant periods of time are required to fill the cleaning vessel. Moreover, when the cleaning process is complete, significant periods of time are required to empty the cleaning vessel of the liquid.

Therefore, there is a need for a cleaning vessel employing megasonic energy for cleaning surfaces of a semiconductor wafer using a supercritical fluid, rather than a liquid, as the working medium.

The is also a need to transform the working medium into the supercritical fluid inside the cleaning vessel. For example, the cleaning vessel can be filled and evacuated over a shorter period of time using a gas instead of a liquid, and the cleaning vessel can be raised above the critical pressure and critical pressure to transform the gas into the supercritical fluid.

Moreover, because the cleaning vessel operates at high temperatures and high pressures, there is a need for providing access to the megasonic transducer producing the megasonic energy. The megasonic transducer is disposed within the cleaning vessel, and, therefore, high pressure electrical feedthroughs have been used to supply the megasonic transducer. However, such high pressure electrical feedthroughs are expensive, and make servicing the megasonic transducer difficult. Therefore, there is a need for access to the megasonic transducer at atmospheric pressures.

SUMMARY

A megasonic cleaning vessel is provided for cleaning a semiconductor wafer, comprising: a top chamber wall; a bottom chamber wall; side walls extending between said top chamber wall and said bottom chamber wall to provide a cleaning chamber; a megasonic transducer provided in said cleaning chamber; a pedestal extending upwardly from said bottom chamber wall for supporting the semiconductor wafer; and an electrical conduit provided through

the cleaning vessel for connecting an electrical cable to said megasonic transducer at atmospheric pressure.

The megasonic cleaning vessel further comprises a transducer housing provided in the cleaning chamber, and is adapted to hold said megasonic transducer. In certain embodiments, the electrical conduit comprises a first electrical cable port provided through the top chamber wall, and a second electrical cable port provided through the transducer housing.

The transducer housing may be formed from a top housing wall, a bottom housing wall, and an interior wall and exterior wall extending therebetween, with the second electrical cable port provided through said top housing wall.

In certain embodiments, the first electrical cable port and the second electrical cable port are joined to form the electrical conduit using a sealing sleeve. The electrical conduit is isolated from the supercritical carbon dioxide contained in the cleaning chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the exterior of the cleaning vessel.

Fig. 2 is a cross-sectional view of the cleaning vessel along Line 2-2 of Fig. 1.

Fig. 3 is a cross-sectional view of the cleaning vessel along Line 3-3 of Fig. 2.

DETAILED DESCRIPTION

Referring to Figs. 1 and 2, the cleaning vessel for cleaning surfaces of a semiconductor wafer is generally indicated by the numeral 10. The cleaning

chamber is formed from a top chamber wall 11, a bottom chamber wall 12 and chamber side walls 14. Together, the top chamber wall 11, bottom chamber wall 12, and chamber side walls 14 define a cleaning chamber 16.

A pedestal 20 adapted to carry the semiconductor wafers extends upwardly from the bottom chamber wall 12 in the cleaning chamber 16. The chamber side walls 14 can be segmented, and together with the top chamber wall 11 form a lid, and together with the bottom chamber wall 12 form a base. The lid could be vertically adjusted relative to the base (from a closed position to an open position) to provide access to the cleaning chamber. Thereafter, the semiconductor wafer can be positioned on the pedestal 20, the lid could be vertically adjusted relative to the base (from the open position to the closed position), and the cleaning process can be initiated. After the cleaning process is complete, the lid could be vertically adjusted relative to the base (from the closed position to the open position) to again provide access to the cleaning chamber 16.

A first electrical cable port 21 extends through the top chamber wall 11 and provides for communication between the exterior of the cleaning vessel 10 and the cleaning chamber 16. As discussed hereinbelow, the first electrical cable port 21 is joined to a second electrical cable port 22 to form an electrical conduit 24. The electrical conduit 24 allows passage of an electrical cable 25 into the cleaning vessel 10. A fluid inlet 28 also extends through the top chamber wall 11. The fluid inlet 28 is attached to piping (not shown), and is used to transport a working medium into the cleaning chamber 16.

A transducer housing 30 is positioned in the cleaning chamber 16. The transducer housing 30 is ring-shaped, and includes a top housing wall 31 and a bottom housing wall 32. Extending between the top housing wall 31 and the bottom housing wall 32 are an interior cylindrical wall 33 and an exterior cylindrical wall 34. A cavity 36 is defined by the top housing wall 31, the bottom housing wall 32, and the interior and exterior cylindrical walls 33 and 34, and a

cylindrical hole 38 through the transducer housing 30 is formed by the interior cylindrical wall 33.

The working medium may be carbon dioxide (CO_2) which is ultimately transformed into supercritical CO_2 inside the cleaning chamber 16. For example, gaseous CO_2 enters the cleaning chamber 16 at pressures above atmosphere. The gaseous CO_2 flows through the fluid inlet 28, and is directed around the transducer 30 and through the cylindrical hole 38. Because the viscosity of gaseous CO_2 is significantly less than the viscosity of liquid CO_2, the gaseous CO_2 is capable of filling the cleaning chamber 16 is a relatively short period of time. After filling the cleaning chamber 16, the gaseous CO_2 is transformed into supercritical CO_2 by raising the pressure and temperature inside the cleaning chamber 16 above the critical pressure (72.9 atmospheres) and critical temperature (31.3° C) of CO_2. During operation, the working fluid is held at pressure and temperatures above its critical pressure and critical temperature, and the supercritical CO_2 is dense enough to conduct megasonic energy, as discussed hereinbelow. Moreover, some organic materials are soluble in supercritical CO_2. Consequently, the supercritical CO_2 is capable of removing such organic materials from the surface of the semiconductor wafer.

A megasonic transducer 40 is provided in the cavity 36. The megasonic transducer 40 is ring-shaped, and produces megasonic energy in the form of high frequency vibrations ranging from 200 to 2,000 Kilohertz. During operation, these high frequency vibrations are directed downwardly through the transducer housing 30 to excite the working medium above the pedestal 20. The high frequency vibrations are transmitted from the transducer housing 30 to the working medium to create a series of pressure waves in the working medium. These pressure waves are conducted by the supercritical CO_2, and are directed downwardly toward the pedestal 20 and the semiconductor wafer carried by the pedestal 20. When applied to the surface of the semiconductor wafer, these pressure waves dislodge remaining particulate materials. Therefore, because the working medium during operation of the cleaning vessel 10 is supercritical CO_2,

some organic materials are dissolved by the supercritical CO_2, and the remaining particulate materials are dislodged by the megasonic energy conducted by supercritical CO_2.

After the organic materials are dissolved and the remaining particulate materials are dislodged, the working medium containing these contaminants ultimately can be evacuated through the fluid inlet 28. However, before evacuation, the pressure and temperature inside the cleaning chamber 16 are lowered below the critical pressure and critical temperature. Consequently, the supercritical CO_2 is transformed into gaseous CO_2, and the gaseous CO_2 (containing the above-discussed contaminants) may be emptied from the cleaning chamber 16 using the fluid inlet 28. As discussed above, the viscosity of gaseous CO_2 is significantly less than the viscosity of liquid CO_2, and therefore, the gaseous CO_2 is capable of being emptied from the cleaning chamber 16 in a relatively short period of time.

The megasonic transducer 40 requires an electrical supply to operate. Therefore, the second electrical cable port 22 is provided through the top housing wall 31 to allow passage of the electrical cable 25 into the cavity 36. For example, a cylindrical sealing sleeve 42 is provided between the top chamber wall 11 and the top housing wall 31. The cylindrical sealing sleeve 42 joins together the first electrical cable port 21 and the second electrical cable port 22 to form the electrical conduit 24. Furthermore, the cylindrical sealing sleeve 42 seals the electrical conduit 24 against the pressure provided in the cleaning chamber 16, thereby providing access to the megasonic transducer 40 at atmospheric pressure through the electrical conduit 24. Consequently, there is no need for high pressure electrical feedthroughs, and the electrical cable 25 can be connected to the megasonic transducer 40 at atmospheric pressure.

It will be understood that embodiments(s) described herein is/are merely exemplary, and that one skilled in the art may make variations and modifications without departing from the spirit and scope of the invention. All such variations

and modifications are intended to be included within the scope of the invention as described hereinabove. It should be understood that any embodiments described hereinabove are only in the alternative, but can be combined.